Laboratory Report Instructions

"Science is not an individual experience... an individual's knowledge properly enters the domain of science only after it is presented to others in such a fashion that they can independently judge its validity."
– On Being a Scientist, the National Academy of Sciences, 1995

Learning to communicate your work in a clear, consistent way using a standard format is part of becoming a scientist or a scientifically literate citizen. Science writing is more formulaic and repetitious than other types of writing. Varying word usage may be desirable in a Humanities paper, but scientists "reject the null hypothesis" with the same phrase every time. The different sections described below will overlap in content and should be understandable no matter what order they are read in. Reading the Figure legends and Table captions should give the reader enough information to be able to interpret the results for themselves.

Among biological sub-disciplines, expectations of format, content, and style differ. Each professor will give more guidelines in the context of each lab.

Some assignments will be done individually, while others are to be done with your lab group. Collaborative work is part of doing science. Group reports should follow these guidelines:

- The # of authors must be <= the # of students that worked together in the lab.
- Work together on the report to ensure consistency across sections.
- DO NOT divide up the sections and meet at the stapler in lab when it is due.
- DO NOT put someone's name on the report if they did not work on the report.
- Each author is responsible for the quality of the entire report.
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The lab report is usually due in your lab section at 1:10pm one week after you perform the experiments. Print your report the night before it is due. Please do not turn in your report to anyone's mailbox. Talk to your lab instructor if circumstances beyond your control keep you from turning in a report on time.

Do not ever represent parts of the textbook or ideas from the literature or other students' writing as your own. This practice, known as plagiarism, is an intellectual crime.

For more detailed information, refer to this book (copies available in labs B5 and B7)

McMillan, V.E. 1997. Writing Papers in the Biological Sciences. 3rd Edition. Bedford/St. Martin's, Boston.

and the American Chemical Society style guide.

http://www.oup-usa.org/sc/0841234620/0841234620_1.html

For general writing tips, The Elements of Style is the classic source.

`http://www.bartleby.com/141/`

One possible arrangement of sections of a scientific paper:

1. Title Page

- an informative report title
- your full name(s)
- a mailbox number for return
- course number
- date report turned in
- laboratory instructor and laboratory day
- signatures of each author indicating that they fully agree with its contents

2. Abstract

This section is the whole paper in a nutshell.

Five to eight sentences arranged in one paragraph as follows:

- the scientific context of your experiment
- what question was asked or what hypothesis was tested
- what you did
- how you did it (brief mention of the methods used)
- what you found (state your results in qualitative terms)
- what it means

3. Introduction

- Give background information on the topic of your experiments.
- What are the questions you are asking, and why are they worth asking?
- Discuss and cite specific experiments done by others if possible.
- Explain the purpose of your experiments.
- Describe variables/treatments used and what was measured/detected.
- State the hypotheses (or null hypotheses) and predictions being tested.
- Italicize Latin binomials with the genus name capitalized and the species name lower-case. *Homo sapiens*
- After the first use, it is okay to abbreviate the genus name. *H. sapiens*

4. Materials and Methods

A knowledgeable scientist should be able to repeat your experiments after reading this combination of text and tables describing the procedures.

- Summarize the procedure that you performed in <u>your</u> <u>own</u> words. This is especially important for deviations from the lab protocol.
- Details like concentrations (in absolute units like mM, not 1x), temperatures, and sample size are important.
- A Table is often useful here to describe the variables/treatments.
- Date, time, and location may be relevant for a field study, but are rarely needed for a lab experiment.
- Any statistical analyses and software used for data analysis should be mentioned.

5. Results (text)

- Restate questions or hypotheses and describe your results (do not list actual numbers, but point out trends or important features).
- "Data" is the plural form of the noun "datum" (use "data are", not "data is").
- Refer to all figures and tables by number as well as any other relevant information. "See Figures." is not sufficient.
- Briefly interpret any analyses and state whether or not you can support specific predictions or reject the null hypotheses if appropriate.
- When statistical tests are appropriate, the normally accepted format for reporting statistical results within text is to give the *Test Name*, *Test Statistic, degrees of freedom* or *sample size,* and *P-value* (e.g. Flower number was significantly higher for unherbivorized plants (ANOVA, $F = 7.232$, $df = 2, 78$, $P = 0.0013$).
- With statistical tests, report the direction of any significant difference or relationship. Which of your treatment groups was larger, greater, or faster? Was it a positive or negative regression slope?
- Results are typically not discussed much more in this section unless brief discussion aids clarity or guides the reader through a series of results.
- If you experienced technical difficulties, you must describe your expectations rather than your actual data or get raw data (not completed figures) from a classmate or the laboratory instructor (remember to cite their source).

6. Results (Figures and Tables)

- Summarize your results in figures or tables as appropriate.
- Do not repeat the same data in both a table and a graph. A graph is preferable.
- Do not simply list your raw data.

Figures

- Graphs, diagrams, and photos are numbered consecutively as Figure 1 to Figure X.
- Label the axes of graphs and define all variables/treatments including units.
- Labels such as "treatments 1,2,3" or "variables A,B,C" are not sufficient.
- A Figure legend is text below the Figure beginning with Figure X and an informative sentence as to the nature of the figure. Include information about methods (temperature, concentration), how the data are expressed, sample size, and any abbreviations.
- Do not include Results or Discussion in the legend.
- Figure legends and labels should make it unnecessary to refer back to the report to understand the information presented.

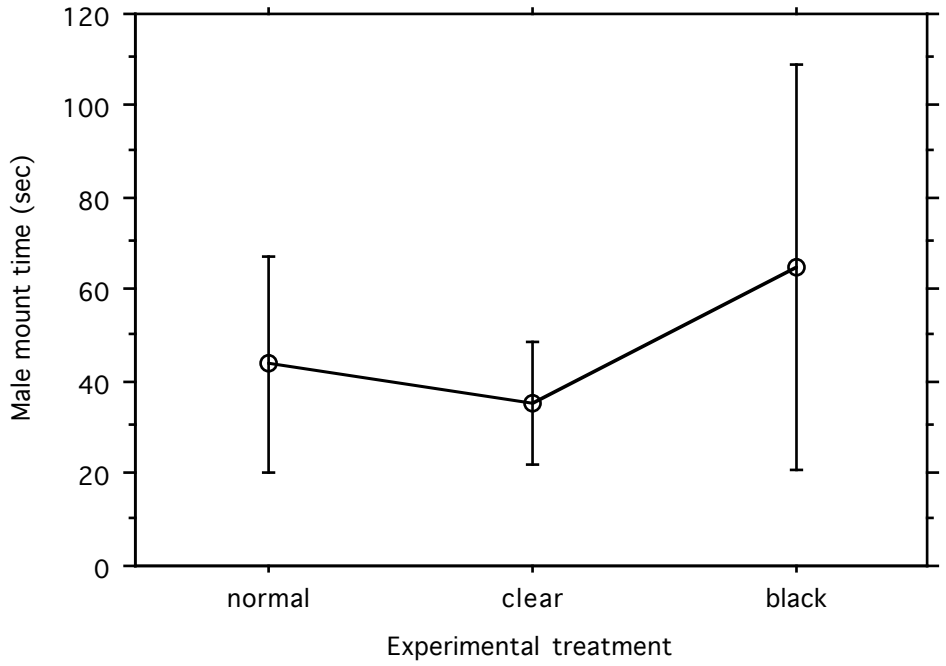

Figure 1. This is the figure legend. It should describe enough of the experiment to allow the reader to interpret the results for themselves without referring to the report text.

- See example report (page R-1) for further examples of Figures and Figure legends.

Tables

- Tables are numbered separately from the Figures as Table 1 to Table X.
- The Table convention is to use columns for categories of information (i.e. size, shape, etc.) and rows for the different entries (i.e. species of bacteria).
- Label the columns and define all variables/treatments including units (do not repeat units within rows of the Table).
- Labels such as "treatments 1,2,3" or "variables A,B,C" are not sufficient.
- A Table caption is text above the Table beginning with Table X and a succinct, one-sentence statement of the contents of the table. Information about methods, how the data are expressed, sample size, or any abbreviations are included as lettered footnotes below the table, keyed to lettered superscripts in the table.
- Table captions and labels should make it unnecessary to refer back to the report to understand the information presented.

Table 1. A table caption is usually shorter than a figure legend and goes above the table.

[KCl] (M)	Lysis[a]	Cell shape[b]
0.8	no	shriveled
0.4	no	shriveled
0.2	no	normal
0.1	partial	swollen
0.05	yes	burst
0	yes	burst

a info about lysis goes here
b info about cell shape goes here
Lettered footnotes go directly below the table (not at the bottom of the page) to give details.

- See example report (page R-1) for further examples of Tables, Table captions, and Table footnotes.

7. Discussion

- Restate questions or hypotheses and describe each general result very briefly. You do not need to refer to Tables, Figures, or P-Values.
- Discuss any expected and unexpected findings in light of the hypotheses and predictions outlined in your introduction or the specific literature (cite references), which prompts your expectations.
- Describe those technical factors that you believe might help the reader interpret your data.
- Critique the experimental design. Does it adequately address the hypotheses being tested? Were there faulty assumptions in the design that confound your interpretation of the data?
- What new questions are prompted by the results?
- If your particular experiment failed, what would you do next time to make it work?
- Include in your text answers to specific questions if listed in the laboratory handout. It is usually a good idea to reflect on these questions as you are obtaining your data.

8. References

For references, the laboratory handout is only a beginning. Seek out original sources, using the references given in laboratory as an entry into the primary literature (peer-reviewed journal articles). Rarely cite textbooks—not only is this déclassé, but information in textbooks is less reliable than in original sources. Use the library (especially the Science Citation Index) to find more detailed information on the topic.

Cite sources within the text of the report

- Avoid the use of direct quotes. Paraphrase and cite the source instead.
- Make sure that all cited references in your report are listed at the end.

In biology papers, information gleaned from the literature is usually paraphrased and the literature source cited by author(s) and date of publication, e.g.:

> Mammalian eggs are generally rather small (Klassen and Black, 1974). Weikert *et al.* (1977) found that monotremes, however, lay large, yolky eggs.

Note that this citing technique indicates that the information came from Klassen and Black's and Weikert *et al.*'s papers, but the statements are not direct quotes, which should be avoided (unless it's Darwin or someone of his stature). For more than two authors, *et al*. is used in the citation, but all authors are included in the reference list at the end.

List all references that were cited at the end

- Alphabetize (by first author's last name) a complete list of references that you cited within your report. Include all authors' names.
- Do not list references at the end if not cited within the text of your report.

Example reference formats:

Book:

Sadava, D., H.C. Heller, G.H. Orians, W.K. Purves, and D. Hillis. 2008. Life

The Science of Biology, 8th Ed., Sinauer Assoc., Inc., Sunderland, MA.

Journal article:

Steinhardt, R. and D. Epel. 1974. Activation of sea-urchin eggs by a calcium ionophore.

Proc. Natl. Acad. Sci. USA 71: 1915-1919.

Chapter in edited book:

Edmunds, M. 1990. The evolution of cryptic coloration. Pp. 3-21 in D. L. Evans and J. O.

Schmidt, eds. Insect Defenses: Adaptive Mechanisms and Strategies of Prey and

Predators, State University of New York Press, Albany.